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# Dutch Elm Disease and its Control in New York State

by Wayne A. Sinclair and John A. Weidhaas, Jr.

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Dutch elm disease is the most important shade tree problem in New York State. Although effective control measures have been known and recommended for 25 years, most communities either have done nothing to control the disease or have failed to carry out technically sound, well-planned control programs.

Municipalities which have maintained such programs have held tree losses to a minimum. This has resulted in: 1) preservation of mature, stately elm trees, 2) preservation of property values, 3) spreading of the cost of tree removals over a period of decades rather than just a few years.

Such communities have provided evidence that effective control of Dutch elm disease is more economical than an inadequate program or no action at all.

## HISTORY

Dutch elm disease was first detected in the United States in 1930 and in New York State in 1933. Two effective insect carriers of the causal fungus were already present in this country when the fungus was accidentally imported with shipments of elm logs from Europe. *Hylurgopinus rufipes* Eichh., the native elm bark beetle, is indigenous to the northern United States and southern Canada. *Scolytus multistriatus* Marsh., the smaller European elm bark beetle, was found first in Massachusetts in 1909 and has since spread throughout much of the range of the American elm. It has become the most common vector (carrier) in all except the more northern areas where the disease occurs.

In the early thirties both state and federal agencies initiated research and control studies in southeastern New York. Much was learned about the beetles, the fungus and disease transmission, although attempts at eradication were unsuccessful. Shortages of manpower and funds during World War II resulted in curtailment of research and control efforts and more rapid spread and intensification of the disease. A control program initiated

after the war by the New York State Department of Agriculture and Markets proved inadequate and was terminated in 1957, leaving the responsibility of initiating and carrying out control measures to municipalities and individual tree owners.

## NATURE OF THE DISEASE

Dutch elm disease is restricted to trees in the elm group and characterized by disruption of normal water relations within trees so that they wilt and die. The disease is caused by a fungus, *Ceratocystis ulmi* (Buism.) C. Moreau, which in New York State is spread to healthy elms by two species of elm bark beetles. The fungus may also be transmitted from a diseased tree to an adjacent healthy tree through roots which have become grafted together underground. Once infected, individual trees cannot be cured, although resistant trees may tolerate infection or even recover.

Three native elm species are common in New York State. The American or white elm, *Ulmus americana* L., is by far the most common and is usually the only native species planted in communities. Slippery elm, *U. fulva* Michx., and rock or cork elm, *U. thomasii* Sarg., grow throughout much of the state but are seldom used as shade trees. All three are highly susceptible to Dutch elm disease. Other species frequently planted in New York include Siberian elm, *U. pumila* L.; Chinese elm, *U. parvifolia* Jacq.; Scotch elm, *U. glabra* Huds.; and varieties of the smooth-leaved elm,


Fig. 1. Foliar symptoms of Dutch elm disease. A) Wilting of green leaves. B) Shrivelled dead leaves adhering to infected twig. C) Early symptoms ("flag") in the crown of an elm.

*U. carpinifolia*, particularly Christine Buisman. Siberian, Chinese and Buisman elms are resistant; Scotch elm is moderately susceptible to the disease.

Dutch elm disease intensifies rapidly in an area after the first few cases are found. If unchecked, the disease is capable of killing more

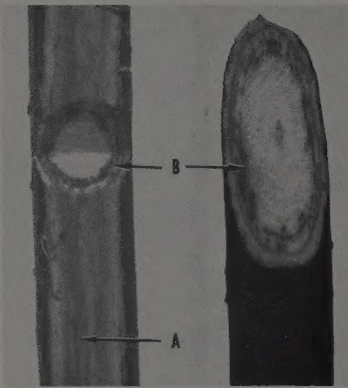



Fig. 2. Discoloration of sapwood is a symptom of Dutch elm disease. A) Uniform discoloration of wood surface beneath bark. B) Streaking in outer sapwood may be detected by a slanting cut (Slightly magnified).

than 90 percent of a local elm population within a 10-year period.

### SYMPTOMS

The appearance of trees infected with Dutch elm disease varies considerably according to the time of year. In June or July elms may show wilting or shriveling of the leaves and new twigs on one or more branches (Fig. 1a,c). Holes or a ragged appearance often seen in leaves are not symptoms of Dutch elm disease. Progress of the disease at this time of year is often rapid, resulting within a few weeks in death of the tree. The wilted leaves may dry out rapidly, turn dull green and fall, or they may turn brown and remain on the tree for some weeks (Fig. 1b).

During midsummer or later, the symptoms are usually confined to a definite part of the tree or even to a few twigs, the leaves curling and/or turning yellow to brown before falling. Trees showing these late-summer symptoms may die during the winter or shortly after they start to leaf out the next spring. Very large trees may live for several years after the first appearance of symptoms. Few, if any, native elms ever recover.

In elms that are low in vigor or partially dead or dying from other causes, the disease symptoms are often obscured except perhaps on the more vigorous parts and on sucker sprouts. Drought conditions and insect or mite attack sometimes produce leaf discoloration, wilting and even leaf-drop during the summer. Such symptoms can easily be mistaken for those of Dutch elm disease. To distinguish, look for "flagging" of individual branches and for definitely wilted and dead brown leaves in contrast to general discoloration or thin foliage throughout the tree.

Internal symptoms of Dutch elm disease appear in the outer layers of wood just beneath the bark. If the bark of a fresh green twig, branch or trunk of a recently infected tree is removed, the outer layer of wood is seen to be mottled, streaked or uniformly discolored brown, gray or almost black (Fig. 2a). From late summer through winter the discoloration is covered by a layer of new wood and is not easily seen unless the wood is cut. In a slanting cut or cross section these discolored areas appear as dark spots or as a continuous dark ring in the wood near the bark (Fig. 2b). Discolorations of any part of the bark are not symptoms of Dutch elm disease.

## THE CAUSAL FUNGUS

*Ceratocystis ulmi* is a microscopic fungus pest specific to elm trees, which it enters through wounds chewed by elm bark beetles or through roots grafted beneath the soil to those of infected trees. There are no other important natural means of transmission. Once inside a tree the fungus grows and multiplies, rapidly producing millions of tiny seed-like spores that are carried throughout the tree in the water-conducting vessels of the wood. The fungus also grows through the tissues of the wood in the form of thread-like filaments. As the fungus thus spreads and multiplies, its parasitic activities disrupt the water-conducting and other processes of the tree, causing irreversible wilting, drying and death of leaves, twigs and branches.

In most elms this process terminates with death of the tree. The fungus, however, remains alive and continues to grow in the wood as well as outward into the inner bark of the dead tree. In any opening or cavity in elm bark or wood that is still moist the fungus produces tiny fruiting structures called coremia (Fig. 3). These consist of strands of dark filaments which produce enormous numbers of sticky microscopic spores at their tips. Coremia with the sticky spores are thus formed in tunnels and chambers chewed out by elm bark beetles, so that as the beetles emerge from the bark, many spores of *C. ulmi* adhere to all parts of their bodies. As the beetles subsequently chew through the bark of a healthy elm, spores are incidentally deposited in the fresh wood, causing infection of the tree.

In the same way spores of the fungus may be introduced by bark beetles into cut elm wood or into dying parts of trees that have not been diseased. Here it grows and produces spores that contaminate the next generation of beetles just as in elm trees that have been killed by Dutch elm disease. It is for this reason that *destruction of all dying or recently dead elm wood,* whether in trees or cut and piled, indoors or out, *is important to prevent the spread and intensification of Dutch elm disease.*

## BARK BEETLES SPREAD DUTCH ELM DISEASE

Two species of bark beetles — the lesser European elm bark beetle, *Scolytus multistriatus* Marsh., and the native elm bark beetle, *Hylurgopinus rufipes* Eichh. — commonly transmit the fungus to healthy elm

Fig. 3. Coremia of *Ceratocystis ulmi* (× 65).

Fig. 4. Development of elm bark beetles. A) Eggs are laid in niches along sides of egg tunnel ($\times$ 10). B) After hatching, young larvae chew tunnels perpendicular to axis of egg tunnel. C) Full-grown larva of elm bark beetle ($\times$ 10). D) Pupa in cell at end of larval tunnel ($\times$ 13).

trees in New York State. Their habits and biology are described here as a basis for understanding the methods of disease control.

Bark beetles multiply by constructing a tunnel between the bark and wood of trees, along which rows of eggs are laid (Fig. 4a). Each egg hatches to produce a grub or larva which chews a tunnel perpendicular to the egg tunnel (Fig. 4b), also between the bark and wood. After the larvae have grown to full size (Fig. 4c) each larva chews a small cell at the end of the larval tunnel in which it transforms through the pupa stage (Fig. 4d) to an adult beetle. Then the mature adult beetle, about 1/8 inch long and 1/16 inch in diameter (Fig. 5a, b), chews its way out through the bark. Adult beetles inadvertently pick up spores of the fungus from within the pupal chamber and carry them on their bodies to healthy trees. Adults of both species do considerable chewing or tunneling in the bark of healthy elms before they seek dying or cut elm in which to tunnel for breeding purposes. The lesser European elm bark beetle chews notches in the very small twig crotches throughout the tree (Fig. 6a, b). The native elm bark beetle chews into the thick bark of tree trunks to hibernate in the winter and also, in late spring, chews in the bark of larger branches from 2 to 10 inches in diameter. When such chewing or tunneling goes deep enough to pass through the cambium and rupture the water-conducting vessels in the wood, spores on the bodies of the beetles can enter the vessels, thus inoculating healthy trees with the fungus.

Although adult bark beetles are strong fliers, they normally travel only short distances from breeding sites to healthy trees. A bit of elm wood containing bark beetles endangers healthy elms within a 200 foot radius. The danger of infection diminishes rapidly with increasing distance from a source of bark beetles. Elms more than 700 feet from such a source are essentially safe.

After chewing in the bark of healthy elms, adult bark beetles seek dying or recently cut elm for breeding. They will fly much greater distances for this purpose, which accounts for long-distance spread of the fungus into previously uninfested areas. It is for this reason that all elm wood suitable for breeding of bark beetles must be located

and destroyed throughout a control area.

Both bark beetle species have great reproductive capacity, a 50-fold increase in numbers being possible in a single generation. Fortunately a number of natural factors such as competition for food, unfavorable weather conditions, predators and parasites prevent the unlimited production of beetles. The most important single factor is the amount of suitable dying or recently cut elm wood available for beetle breeding. Prevention of the build-up of a large beetle population through elimination of dying and recently dead elm wood is the major objective of any Dutch elm disease control program.

**The lesser European elm bark beetle.** The adult, which is about 1/8 inch long, cylindrical and shining red-brown in color, is illustrated in Figure 5a. The hind end of the body is distinctly concave with a peg-like projection. The larva (Fig. 4c) is white and legless and about the same length as the adult when fully grown. The pupa (Fig. 4d) is white and shows the developing wing and leg structures of the adult.


Fig. 6. Adult European elm bark beetles feed in one-year-old twig crotches. A) Beetle beginning to feed (× 4). B) Typical feeding wound showing exposed wood (× 4).

The egg tunnel of this species is 1 to 2 inches long and oriented with the grain of the wood; larval tunnels cross the grain of the wood but seldom cross each other (Fig. 7a).

The winter period is passed in the larval stage which remains inactive until the temperature of the bark rises in spring. Then the larvae resume feeding and transform into adults which tunnel to the surface of the bark and emerge beginning in early May through small holes in the bark. Initial emergence dates may differ by 7 to 14 days from one part of the state to another. The peak of beetle emergence occurs in mid to late May and continues well into June. A second generation begins to mature in late July. Adult beetles of this generation are active in August and September, laying

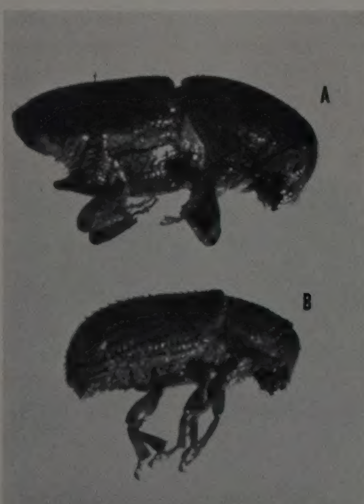



Fig. 5. Adult elm bark beetles. A) *Scolytus multistriatus.* B) *Hylurgopinus rufipes,* (× 15).

eggs which produce the overwintering larvae. It is the spring flux of beetles which is responsible for the majority of infections of elms since the trees are most susceptible to the fungus during late May and June. Relatively few infections of healthy elms result from the tunneling of the summer generation on healthy trees.

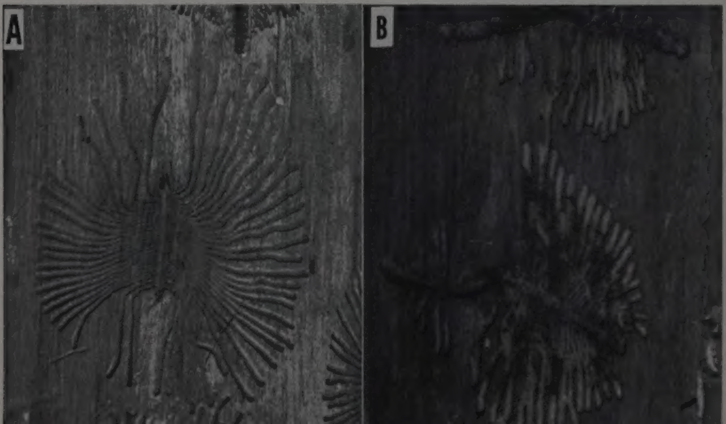
**The native elm bark beetle.** The adult of this species is slightly less than 1/8 inch long and dull brown in color (Fig. 5b). The wing covers are rough and the hind end of the body is rounded, lacking a peg-like projection. The eggs, larvae and pupae closely resemble those of the lesser European elm bark beetle. Breeding habits are essentially the same in both species.

The gallery produced by the native elm bark beetle can readily be distinguished since the egg tunnel always crosses the grain of the wood and usually contains an angle (Fig. 7b). Larval tunnels run generally with the grain and cross one another frequently in contrast with non-crossing of larval tunnels of the lesser European elm bark beetle.

Life cycle and seasonal development of the native elm bark beetle are more complex than those of the lesser European elm bark beetle. Two cycles or broods develop concurrently. Winter is passed by one brood as adults and by the other as larvae. Each brood produces a second generation which develops only partially before the next winter.

The partially developed overwintering larvae require a longer period in the spring to reach maturity than do larvae of the lesser European elm bark beetle. Adults from this brood emerge in late June and July. These adults do not feed in crotches of twigs but tunnel into the bark of branches and limbs of healthy trees. They then fly to recently cut or dying elm wood, in which they chew egg tunnels. Larval development takes place during the remainder of the summer. Adult beetles emerge after pupation, usually in September, and fly to the trunks or main limbs of healthy trees. These beetles

Fig. 7. Egg tunnels and larval galleries of elm bark beetles. A) *Scolytus multistriatus*, B) *Hylurgopinus rufipes*.



tunnel deep into the live bark where they hibernate for the winter.

Hibernating beetles become active in early spring when bark temperatures rise. They tunnel further in the thick bark of the trunk and then emerge in late April and early May. Many fly to branches and limbs where they again tunnel in live bark. It is this tunneling which causes inoculation of the trees with spores of the fungus.

## DISEASE RELATIONSHIPS

Elms are most susceptible to Dutch elm disease from late May through early July. It is during this period when the fungus is able to spread most rapidly from a point of introduction (beetle feeding wound or root graft). The fungus spreads through the large water-conducting tubes (vessels) formed during the early part of the growing season and located at that time immediately adjacent to the bark (Fig. 8). As the growing season progresses, the tree produces wood that is more dense and in which the vessels are much smaller (summerwood, Fig. 8). Elms are most susceptible when the large vessels are still close to the bark and therefore likely to be ruptured by chewing bark beetles. Although the beetles may continue to chew through the bark to the wood during the entire growing season, introducing spores of the fungus at any time, infections of the dense summerwood seldom persist to cause conspicuous damage to a tree.

The dark streaking in the wood which is a symptom of Dutch elm disease is caused by the destructive activities of the fungus in the large

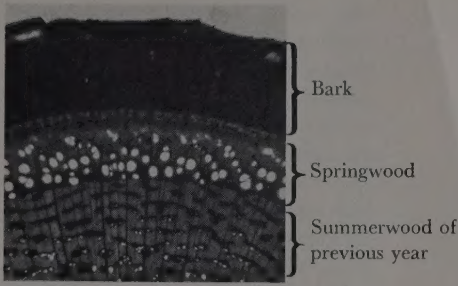



Fig. 8. Cross-section of elm twig, showing large springwood vessels through which Dutch elm disease fungus spreads (× 7).

vessels and the adjacent cells.

Elms have spreading and relatively shallow root systems which in the absence of physical obstructions commonly extend away from the trunk to a distance greater than the height of the tree. Individual roots often become grafted to those of adjacent elms *of the same species*, particularly where trees are separated by 30 feet or less. Such root grafts provide direct channels for the passage of the Dutch elm disease fungus from an infected tree to a healthy one. Thus the disease may progress along a row of closely spaced trees without the usual requirement of fungus transmission by elm bark beetles.

### Summary of the Disease Cycle

1. Elm bark beetles contaminated with spores of the Dutch elm disease fungus chew through the bark of twig crotches, trunks and branches of healthy elms, and in so doing incidentally deposit spores in the water-conducting vessels.
2. The fungus multiplies and spreads throughout the tree, causing

its death. It may also spread through root grafts to healthy trees. A tree may be killed rapidly or the disease may progress branch by branch and take several years to kill the entire tree. The fungus remains alive and grows throughout the bark and wood after death of the infected branch or tree.

3. As any part of a tree approaches death it becomes attractive to adult bark beetles which tunnel between the bark and wood, breed and lay eggs, thus providing for a new generation of beetles. These beetles become contaminated with spores. Bark beetles also lay eggs in elm wood which is recently dead or dying from other causes. Since adult beetles may be contaminated with spores of the fungus at all times, they inadvertently carry the fungus into new uninfected breeding wood as they tunnel, insuring that the next generation of beetles will also be contaminated whether or not they are reared in wood from diseased trees.

4. The new generation of adult bark beetles chews through the bark of healthy elms the next spring, introducing spores of the fungus into the wood and beginning the cycle anew.

## CONTROL

Control of Dutch elm disease depends upon suppression of local populations of the elm bark beetles that carry the causal fungus. This is accomplished by destroying elm wood which is suitable for the breeding and egg-laying activities of the beetles, a procedure called *sanitation*. The objective of this method is to eliminate potential sources of fungus-contaminated beetles within 700 feet of trees to be protected. Recall that 700 feet is about the maximum distance that beetles fly to feed on twigs and branches of healthy elms. *Effective sanitation alone can keep Dutch elm disease losses in a community to less than 2 percent of the elm population per year.*

There are also a number of supplementary measures which can be used in conjunction with sanitation to provide for increased protection of particularly valuable trees within areas covered by sanitation programs. Chief among these are control of bark beetles by insecticides, and chemical killing of roots between diseased and healthy elms to prevent root-graft transmission of the disease.

### Sanitation Program

Requirements of an effective sanitation program are outlined below:

1. Designate a specific area within which elms are to be protected.

2. Thoroughly scout the entire area plus a zone 700 feet wide around it to locate all elm wood which is suitable for the breeding of elm bark beetles. Breeding wood includes all dying or dead elm wood 2 inches or more in diameter on which the bark is still tight. Smaller material dries out too rapidly to produce beetles; older wood on which the bark is loose is no longer suitable for beetle breeding. Types of elm material to look for are:

   a) Dead, dying or obviously weakened elm trees, regardless of species or variety.

b) Dead, dying or obviously weakened branches in otherwise healthy elms.

c) Stumps of cut trees (These are of no consequence if the bark has been removed).

d) Elm wood cut from trees, whether or not they were diseased. Look particularly for elm in cut and piled fireplace wood, whether stored indoors or out, since the insects will escape from closed rooms, cellars or garages as well as from piles in the open. This will require the *education and cooperation of individual property owners, without which the entire program will fail.*

3. Destroy breeding wood. This may be done in several ways:

a) Burn it or remove and burn the bark, but *do not keep elm wood for fuel unless all bark has been removed and destroyed.*

b) Bury it under at least 12–18 inches of soil.

If it is impractical or impossible to carry out any of these methods, two others may be used, preferably in combination.

1. Remove all breeding wood from the sanitation zone, or,

2. Treat the bark with a soaking spray consisting of a solution of 8 gallons of 25 percent DDT concentrate and 92 gallons of No. 2 fuel oil. This spray kills all vegetation with which it comes in contact and is highly inflammable until thoroughly dry. Because of these objections and because of the difficulty in reaching the undersides of large logs, this method of treating beetle breeding wood is not recommended except as a last resort. Less effective but less objectionable is a mixture of 8 gallons of DDT emulsifiable solution and 92 gallons of water.

**Positive diagnosis of Dutch elm disease.** Since infected trees usually die, and since any dying elm wood is important in the spread and intensification of the disease, positive diagnosis of Dutch elm disease in a tree is of little importance in control. Positive identification cannot be made in the field because there are two other less important diseases of elms which cause identical symptoms in infected trees. The three diseases can be distinguished only by laboratory tests involving isolation and identification of the respective causal fungi. In practice, such laboratory tests are carried out only when there is some important reason, usually a legal question, for proving the cause of a tree's dying.

If positive identification of the disease is needed, laboratory tests can be performed on twig samples of freshly-diseased wood. The material should be prepared as follows: Select several twigs about 1/2 inch in diameter and 5 to 6 inches long from several recently wilted but not yet dead branches. The samples must show the characteristic streaks or discolored areas in the wood just beneath the bark. If several trees are to be sampled, it is well to disinfect the cutting tool with denatured alcohol each time it is used on a new tree. Samples should be wrapped tightly in polyethylene or

other material to prevent drying, and each should be labelled with the location, name and address of the collector, the date and the reason why diagnosis is necessary. The whole sample should be sent by first-class mail to the Department of Plant Pathology, Cornell University, Ithaca, New York, 14850. *Samples will not be tested unless the request shows a clear need for specific diagnosis.*

### Supplementary Control Measures

Supplementary measures for control of Dutch elm disease should be carried out by communities only after all requirements of the sanitation program have been met. Manpower and funds should not be diverted from the main program.

**Dormant spraying of healthy elms.** The treatment of healthy elm trees with an insecticide to prevent infection through beetle feeding is a supplementary measure to sanitation. Selected trees of high value within sanitation zones in communities can be sprayed to provide added protection against infection. Spraying is the only alternative for privately owned trees, particularly where a sanitation program is not in effect. However, spraying alone is not an effective substitute for sanitation, and the chances are greater in an area of high disease incidence and beetle breeding that even sprayed trees will become diseased. It is important to do everything possible to save highly valuable, large old elms.

Dormant elm bark beetle sprays must be applied with a large mist blower or hydraulic sprayer before the leaves come out. Such treatments are expensive and difficult to apply at the proper time and in an effective manner. There is no bargain price for a thorough spray job. A reputable, established arborist should be engaged under contract to apply dormant sprays to elm trees.

Mist blower applications are preferred, although hydraulic spraying is not so limited by wind conditions. Mist blowing results in less runoff, drift, and puddling of the insecticide. DDT is the most effective insecticide against elm bark beetles and provides residual protection for several months or longer. Methoxychlor is an acceptable substitute for DDT and may be preferred since it is much less toxic to birds and animals and does not accumulate in the bio-chain as DDT does.

Sprays for mist blowers should be at 12.5 percent solution by weight of DDT or methoxychlor in water. This is obtained by mixing 50 gallons of a xylene or xylene-type base 25 percent emulsifiable concentrate with 50 gallons of water, resulting in 100 lbs of the insecticide in 800 lbs of water, approximately. From 2 to 5 gallons of this mist concentrate are applied to each tree, depending on its size. An average tree 65 feet tall with a somewhat limited branch spread requires about 2 to 3 gallons of spray. At an average cost of \$1.35 per gallon of spray concentrate, 2 to 5 gallons per tree would average \$1.35 to \$3.00 for insecticide chemical alone. Labor and equipment costs are substantial. It is more expensive to spray individual trees

than to spray under contract in municipalities.

With a mist blower, adequate coverage can be obtained only when there is *no wind*. Zero wind conditions are infrequent in New York State during March and April and occur mainly at night or before 8 o'clock in the morning. Mist blowers should be equipped with spot lights. Spraying can be done with temperatures as low as 25° F. Usually windless nights in March and April occur when there are high pressure air masses with temperatures at or below freezing. Rates of application are determined by the manner in which the air column from the blower is manipulated, the length of time each tree is sprayed, and the delivery rate at the nozzle. Prior to starting the flow of spray, a column of air into the tree should be established. Then the spray is turned on, using 3 or 1½ minutes to spray each average-sized tree with a 1 or 2 gallon per minute nozzle respectively. *Only a skilful, experienced and conscientious operator can properly apply this spray.*

In a hydraulic-type sprayer, capable of delivering at least 50 to 60 gallons per minute, a 2 percent spray solution of DDT or methoxychlor should be used. This is obtained by mixing 8 gallons of a 25 percent emulsifiable concentrate with 92 gallons of water. As with mist blowers, thorough spraying is essential.

DDT sprays are likely to lead to increased trouble from mites, aphids, and certain scales. Addition of an acaricide with dormant treatments is *not* effective against these other pests which appear later in the season. European elm scale and scurfy scale have not been a problem where dormant DDT has been applied. Dormant spraying is likely to cause some killing of buds, but the percentage is low. Dormant elm bark beetle sprays are not recommended for use in community-wide projects.

**Prevention of fungus transmission through root grafts.** In communities with effective sanitation programs a large proportion of new infections may occur because of transmission of the Dutch elm disease fungus from the roots of infected trees to adjacent healthy trees through root grafts. The frequency of this type of transmission varies with the spacing of the trees. It is most likely to occur when the spacing is 30 feet or less. Root graft transmission can often be detected by the pattern of wilt symptoms which may first appear on small branches along the trunk or low in the crown rather than at the top of the tree.

This type of transmission can be sharply reduced by chemically killing tree roots in a narrow zone between infected and healthy trees. This is done by applying a soil fumigant chemical, sodium N-methyl dithiocarbamate (available commercially as Vapam or VPM) in a row of holes drilled in the soil between two trees. The chemical kills all roots in a band extending a few inches on either side of the row of holes. The Dutch elm disease fungus does not pass through the killed root sections. The procedure also causes death of grass in a band several inches wide or in circular

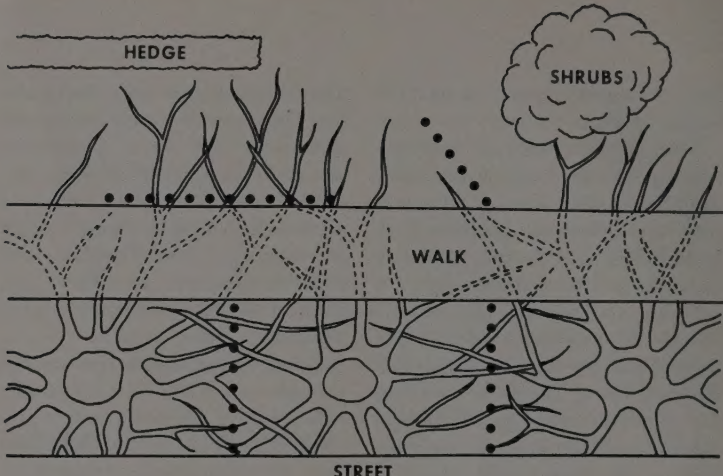



Fig. 9. Two patterns for application of soil fumigant to prevent root-graft transmission of Dutch elm disease.

spots a few inches in diameter around each hole. These dead spots can be reseeded or sodded 4 to 6 weeks after treatment.

An estimate of the need and feasibility of the treatment can be obtained from scouting reports compiled in conjunction with the sanitation program. If elms are closely spaced and current incidence of Dutch elm disease due to root graft transmission appears to be a significant proportion of the total, fumigant treatment should be considered. Communities with large numbers of elms should try the method on a small scale first in order to appraise its economic soundness. Details of the method follow:

1. Immediately after symptoms of Dutch elm disease are discovered in a tree, isolate it from healthy trees by the fumigant treatment. Early detection of the disease is important to success. Areas in a community where elms are closely spaced should be scouted every two weeks during June, July and August in order to detect trees in an early stage of wilt. If a diseased tree is less than 20 feet from a healthy elm or has advanced wilt symptoms, it may be necessary to treat at two sites, one between the diseased and first healthy tree and one between the first and second healthy trees. This measure is advised because the fungus may already have passed into the roots of the first healthy-appearing elm before the fumigant treatment takes effect. Soil temperature must be above 50°F for the treatment to be effective.

2. Prepare the fumigant. Vapam or VPM, available as a 32.75 percent solution, is diluted 1 part of the chemical to 3 parts of water, or 1 quart of chemical per gallon of dilute solution. The chemical should be handled and prepared only by personnel trained in the safe use of pesticides. A convenient method is to prepare several gallons of dilute solution in a tank or drum equipped

with a tap, from which smaller quantities can be loaded into a garden-type compressed air sprayer from which the nozzle has been removed. The liquid can then be dispensed into the holes at low pressure.

3. Drill a row of holes 3/4 inch in diameter and 18 inches deep in a straight line 6 inches apart midway between the trees. Where sidewalks are present the holes should be slanted under the walks. The row of holes should extend to slightly beyond the drip line of the trees. If other kinds of plants are present and interfere with application in a straight line of holes, alternate patterns of holes may be used as shown in Figure 9. Do not apply the chemical within 5 feet of shrubs or 25 feet of other tree species.

4. The liquid is applied at the rate of 1/2 cup of dilute solution per hole (equivalent to 1/4 cup of the 32.75 percent solution per linear foot). Apply the chemical carefully to avoid overflowing the holes. This will reduce grass kill.

5. Tamp each hole closed with the heel to prevent gas dissipation.

6. To allow time for cessation of sap flow through the poisoned root sections, allow at least two weeks after treatment before removing the diseased tree.

### Timetable for Control Operations

**Scouting for diseased trees and beetle breeding wood:** — June 15 — July 31. The sanitation program will be best served if the sanitation zone is scouted twice during this period. Scouting is more difficult in August and September because active wilt symptoms are usually absent. Yellowing and leaf drop, characteristic of many elm troubles in addition to Dutch elm disease, are the rule.

**Destruction of beetle breeding wood:** As soon as practicable after scouting has started, but in any event before April 15 of the next year. The job will be more thoroughly done if work is distributed through the year rather than attacked shortly before a deadline.

**Dormant spraying for control of bark beetle feeding:** Most effective when applied under optimum weather conditions during March and April, no later than when leaf buds break and leaves start to grow. Mist blower sprays applied after November 1 may provide protection through the next May and early June only if sprays are heavy and thorough. Fall sprays must be applied after leaves have fallen.

**Fumigant treatment to prevent spread through root grafts:** As soon as possible after detection of disease.

### Protection of Elms Outside of Sanitation Zones

Although maximum protection of elms against Dutch elm disease requires efficient sanitation throughout an area, some protection of trees outside of such areas can be had by employing the supplementary measures discussed earlier. Dormant spraying is the most important of these. However, destruction of breeding wood in and near an individual tree still has importance since beetles tend to feed on healthy elms nearest the breeding wood from which they emerge.

### Elms Resistant to Dutch Elm Disease

Although none of the many species of elm trees are immune to Dutch elm disease, some are highly resistant or contain resistant varieties. None of these, however, develop the large size and vase-shaped form of the American elm. Some of the resistant species and varieties which are available and can be grown in New York State are listed below.

| | |
|---|---|
| Siberian elm | *Ulmus pumila* |
| Chinese elm | *Ulmus parvifolia* |
| Scotch elm | *Ulmus glabra* (not highly resistant) |
| Buisman elm | *Ulmus carpinifolia* var. Christine Buisman |
| Groeneveld elm | *Ulmus hollandica* "Groeneveld" |

*These elms must be included in sanitation programs,* but removal of an entire infected tree may not be necessary.

## LOOKING AHEAD

**The future of American elms.** In unincorporated areas and in communities lacking complete control programs it seems only a question of time before all large elms succumb to Dutch elm disease. Because of its prolific seeding habits and rapid growth, the American elm can be expected to survive in hedgerows and wooded areas, although few trees will reach large size and their numbers will be sharply reduced.

Annual losses in some municipalities have been kept to 1 or 2 percent of the original elm population by carefully planned and executed control programs. A few communities are even using American elms for some of their shade tree replacements. These local efforts have insured that the American elm will be very much a part of the local scene for decades to come.

**New methods of control.** Each year a number of new "cures" and preventive treatments for Dutch elm disease receive considerable publicity. Most of these when tested by competent scientists are eventually proved worthless for control of the disease. However, research to develop effective new methods for control is continuing at many laboratories and experiment stations. If the effectiveness of any new method or treatment is demonstrated, recommendations for control of Dutch elm disease in New York will be altered to include it. To check on the accuracy of publicity about new control methods, contact the office of the Cooperative Extension Service Association in your county. The Cooperative Extension Agent has up-to-date information about any changes in recommendations for control of Dutch elm disease.

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